North American Journal of Fisheries Management 1996, v.16, n.2, pp.378-387
Online ISSN: 1548-8675
Print ISSN: 0275-5947
http://afs.allenpress.com/perlserv/?request=get-archive
http://afsjournals.org/doi/pdf/10.1577/1548-8675(1996)016%3C0378%3AFASOAS%3E2.3.CO%3B2

North American Journal of Fisheries Management 16:378–387, 1996

Factors Affecting Survival of Age-0 Saugeye *Stizostedion vitreum* × *S. canadense* Stocked in Ohio Reservoirs

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Abstract.—To explain variable stocking success of juvenile saugeye *Stizostedion vitreum* females × *S. canadense* males, we quantified survival of saugeyes in response to transport conditions, predation mortality, and prey resources at stocking in four Ohio reservoirs (162–1,145 ha) in 1991. May through October survival was 0.8–11.5%. We assessed stresses associated with transportation and handling by holding fish in small enclosures 5–10 d poststocking. Enclosure mortality varied greatly (18.9–63.5%), and because enclosures inadequately mimicked the reservoir environment, transportation and handling mortality were likely overestimated. Mortality resulting from resident piscivores was calculated via population estimates and poststocking sampling. Predation on age-0 saugeyes was minimal during poststocking sampling, ranging from 0 to 28.3% of the stocked population. Saugeye survival was statistically unrelated to zooplankton or ichthyoplankton (i.e., larval gizzard shad *Dorosoma cepedianum*) densities, although both ichthyoplankton density at stocking and saugeye growth showed positive trends with saugeye survival. Ichthyoplankton availability likely influences growth and survival of saugeyes; therefore, saugeye stocking should coincide with peak ichthyoplankton densities.

Because saugeyes, the hybrid of walleye *Stizostedion vitreum* females × sauger *S. canadense* males, have improved growth and production characteristics when compared to walleyes during culture (Malison et al. 1990) and in reservoirs (B. L. Johnson et al. 1988), they have become the primary sportfish stocked into Ohio reservoirs (B. L. Johnson et al. 1988; Culver et al. 1992, 1993). However, because of limited reproduction (Siegwarth and Summerfelt 1990) and high catch rates, saugeye populations must be maintained via annual stocking of pond-reared, age-0 fishes. Although saugeyes have produced impressive fisheries in some Ohio reservoirs (R. Schaefer, Ohio Division of Wildlife, personal communication), their stocking success has varied greatly from year to year and lake to lake.

Hypotheses to explain this variability center around those typically associated with any stocked fish (Wahl et al. 1995), including handling mortality (Mather et al. 1986; Mather and Wahl 1989), predation by resident fishes (Stein et al. 1981; Carline et al. 1986; B. L. Johnson et al. 1988; Wahl and Stein 1989), and conversion of their diet to appropriate prey species (Gillen et al. 1981; Carline et al. 1986; B. M. Johnson et al. 1988). Mortality from handling and temperature stress initially was assessed for percids stocked into Ohio reservoirs. In one reservoir, some stocked walleyes and saugeyes died immediately upon release from the hatchery truck each year (B. L. Johnson et al. 1988); in a second reservoir, immediate hauling mortality of walleyes was 1–5% in 1979 to 1982, whereas stress-related mortality was 17–32% after 6–7 d in predator-free enclosures (Hurley and Austin 1987).

Predation by resident fishes, including largemouth bass *Micropterus salmoides*, smallmouth bass *M. dolomieu*, white crappie *Pomoxis annularis*, black crappie *P. nigromaculatus*, catfishes *Ictalurus* spp., white bass *Morone chrysops*, esocids *Esox* spp., and yellow perch *Perca flavescens*,

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TABLE 1.—Characteristics of saugeyes stocked at a density of 250/ha in Ohio reservoirs during 1991, including stocking date and water temperature. Saugeye characteristics include total length (N = 30 per lake), wet weight (N = 30 per lake), and condition factor (K). Standard errors are given in parentheses.

Reservoir			Water	Saugeye characterstics		
Name	Size (ha)	Stocking date	temper-ature, °C	Total length, mm	Wet weight, g	K,[a] g/mm^3
Pleasant Hill	344	14 May	22.5	33.5 (0.37)	0.265 (0.008)	0.701 (0.013)
Caesar Creek	1,145	21 May	22.5	33.7 (0.43)	0.214 (0.009)	0.555 (0.015)
Logan	162	29 May	28.0	38.5 (0.90)	0.320 (0.028)	0.528 (0.009)
Delaware	526	4 Jun	25.8	39.4 (0.63)	0.342 (0.017)	0.548 (0.007)

[a] $K = 10^5 \times$ (weight, g)/(length, mm)^3.

as well as adult walleyes and saugeyes, could dramatically influence survival of stocked saugeyes, as it does esocids (Wahl and Stein 1989). Preliminary research in an Ohio reservoir revealed that 6–49% of sampled predators contained age-0 percids (either walleyes or saugeyes; Hurley and Austin 1987; M. R. Austin, Ohio Division of Wildlife, unpublished data).

Seasonal patterns and availability of reservoir zooplankton and ichthyoplankton may influence saugeye growth and survival. Saugeyes reared in ponds on zooplankton typically convert to a diet of fish and large macroinvertebrates within a week after stocking (B. L. Johnson et al. 1988). If this conversion is delayed, zooplankton availability immediately after stocking could be critical to the initial success of percids (Fox 1989), even though piscivory is possible in percids of the size generally stocked into Ohio reservoirs (≥30 mm; Mathias and Li 1982; Stahl and Stein 1994). Piscivory increases condition and survival of largemouth bass (Wicker and Johnson 1987) and zander *S. lucioperca* (Buijse and Houthuijzen 1992); thus, availability of prey to larval fish may be important immediately poststocking. Age-0 gizzard shad *Dorosoma cepedianum* were the primary prey for age-0 saugeyes stocked into an Ohio reservoir during 1979 through 1982 (B. L. Johnson et al. 1988).

To explore reasons for variable stocking success, we quantified transportation and handling stress, losses to resident predators, prey availability, and saugeye diets in four Ohio reservoirs in 1991. By quantifying mechanisms underlying variability in saugeye survival, we should be able to modify stocking strategies to improve the saugeye sport fishery.

Study Sites

Saugeyes were stocked into four Ohio onstream impoundments: Pleasant Hill Reservoir (344 ha; Richland and Ashland counties), Caesar Creek Lake (1,145 ha; Warren, Clinton, and Greene counties), Lake Logan (162 ha; Hocking County), and Delaware Reservoir (526 ha; Delaware, Marion, and Morrow counties). These reservoirs were chosen because of their relative physical similarity (size, depth, etc.) and their history of variable stocking success. On the basis of fall 1985–1990 catch-per-unit-effort data from the Ohio Division of Wildlife for saugeyes stocked in spring (Austin, unpublished data), survival in these reservoirs is variable and can be ranked from good to poor in the following order: Pleasant Hill Reservoir, Caesar Creek Lake, Delaware Reservoir, and Lake Logan. Average depth varied from 2.8 m in Lake Logan to 11 m in Caesar Creek Lake. Mean summer (April–October) Secchi disk transparencies ranged from 0.5 m in Delaware Reservoir to 4.3 m in Caesar Creek Lake. Few aquatic macrophytes occurred in any reservoir. Gizzard shad dominated the piscine forage base of all reservoirs.

Methods

Age-0 saugeyes were stocked at a density of 250/ha into four Ohio reservoirs from mid-May through early June 1991 (Table 1). Fish were reared in ponds at the Hebron State Fish Hatchery, Ohio Division of Wildlife. Thirty fish per reservoir were measured to the nearest millimeter total length (TL) and weighed to the nearest 0.01 g to determine condition factor ($K = 10^5 \times$ [weight, g]/[length, mm]^3; Ricker 1975) of stocked fish (Table 1). We estimated the number stocked by weighing 200 g of fish (about 325 individuals), counting them, weighing all fish, and extrapolating the number in our sample to the number stocked. Fish were transported in aerated solutions (0.5% salt) of pond water and stocked at one point in each reservoir. Water temperature varied less than 2°C between hatchery and reservoirs. We estimated immediate poststocking mortality by inspecting the stocking site for dead fish about 1 h after stocking.

Transportation and handling.—To estimate losses from transportation and handling, 80 saugeyes (mean per lake, 33.5–39.4 mm) from those being stocked were placed in two floating enclosures (1.2 × 0.6 × 0.7 m with 3-mm black plastic mesh) with two compartments each (N = 20 per compartment) on the stocking day for each reservoir. Fish were monitored daily for 5–10 d to assess poststocking mortality.

To analyze enclosure effects on saugeyes, two additional enclosures with 80 saugeyes were placed in Delaware Reservoir. Twelve saugeyes were taken from these enclosures every other day; length (nearest mm TL) and weight (nearest 0.01 g) were measured, and stomachs were removed for dietary analysis. These data were compared to those of at-large saugeyes.

Predation on saugeyes.—Potential predators, including crappies, catfishes, white bass, esocids, yellow perch, and yearling and older saugeyes were trap-netted 1–2 months before stocking for modified Schnabel mark–recapture population estimates (Ricker 1975). The entire perimeter of each reservoir was electrofished with a 230-V pulsed DC boom shocker to sample largemouth bass and smallmouth bass for modified Schnabel mark–recapture population estimates in Pleasant Hill Reservoir and Lake Logan, and for Petersen estimates in Caesar Creek Lake and Delaware Reservoir. All predators larger than 80 mm TL were measured (nearest mm), marked with a caudal fin clip, and released.

To estimate the actual consumption of age-0 saugeyes, potential predators were electrofished for three consecutive nights poststocking and once per week for two additional weeks. Gill nets also were set for less than 3 h at least twice daily for three days or nights poststocking at Caesar Creek Lake and Delaware Reservoir to sample pelagic predators (primarily crappies and white bass) invulnerable to electrofishing gear. Gill nets were not set in Pleasant Hill Reservoir or Lake Logan because pelagic predators were scarce in these reservoirs. Predators were measured (nearest mm, TL) and weighed (nearest g); their stomach contents were then removed by pulsed gastric lavage (Foster 1977), and food items were identified and measured (nearest mm, TL). Food items not identifiable in the field were preserved on wet ice and examined later.

We estimated mortality from predation by dividing predators into 50–100-mm size-classes and multiplying the number of saugeyes per predator per day by the population of the predator size-class. Number of saugeyes per stomach during our sampling period was doubled to account for two feeding periods per day for the predators. For days when predators were not sampled, the predation rate was estimated by simple interpolation. For each predator size-class, we assigned the minimum non-zero predation rate from sampling as the predation rate for the period after sampling through 8 weeks poststocking.

To further assess how pelagic predators influence age-0 saugeye survival, two upground reservoirs, Riley and Wauseon 2, were stocked with age-0 saugeyes (25–35 mm) at a rate of 250/ha in May–June 1992. Pelagic predators were age-1 or older saugeyes in Riley Reservoir (12 ha, Crawford County; stocked 12 May 1992) and white bass in Wauseon 2 Reservoir (18 ha, Fulton County; stocked 2 June 1992). Both predator populations and poststocking predation rates were estimated as just described.

Prey availability and saugeye diet.—To determine the relative timing of zooplankton blooms and declines in reservoirs relative to stocking dates, zooplankton was sampled weekly from mid-April through October at three or four sites per reservoir with one vertical tow of a 53-μm-mesh Nitex, 31-cm-diameter plankton net. Sampling sites were assigned near the stocking site and at other sites throughout the reservoir to provide forage estimates for all areas accessible to saugeyes. Zooplankton was preserved in 5% sucrose formalin (Haney and Hall 1973) and counted as described in Stahl and Stein (1994).

Ichthyoplankton was collected weekly in two replicate surface tows at zooplankton sampling sites for large reservoirs (Caesar Creek Lake and Delaware Reservoir) or between zooplankton sites for small reservoirs (Pleasant Hill Reservoir and Lake Logan) with a 500-μm-mesh Nitex, 75-cm-diameter plankton net towed offshore during the day for 3–5 min at 1.5 m/s. A General Oceanics flowmeter mounted in the mouth of the net provided estimates of water volume filtered. Ichthyoplankton was sampled from mid-April through October and preserved in 10% formalin.

We analyzed ichthyoplankton samples by counting at least 200 gizzard shad in a known proportion of the entire sample. If samples were sufficiently dense to prevent counting on a circular, pie-sectioned dish, we initially subsampled using a Folsom plankton splitter (Wildlife Supply Company, Saginaw, Michigan). Once we were able to count on the dish, we completely counted the wedge in which the 200th gizzard shad was found and then calculated the proportion of the total sample counted. From this, we calculated total number of shad per sample (number of individuals counted divided by proportion counted). Ichthyoplankton length was not measured. Non-shad species were counted but not distinguished from one another because of their low density ($<0.15/m^3$).

We sampled age-0 saugeyes weekly through October by shore seining during the day (4.6 × 1.8 m or 18.4 × 1.8 m, 3.2-mm mesh). Night electrofishing was used as fish became less vulnerable to seining in July. Two seine sites were selected near each zooplankton collection station with a goal of capturing 10 saugeyes per site. Captured saugeyes were preserved on wet ice in the field for later laboratory analysis. Lengths (nearest 0.5 mm TL), wet weights (nearest 0.001 g) with stomach contents, and dry weights (dried at 60°C for 24 h; nearest 0.001 g) without stomach contents were measured for each saugeye. Prey in stomachs were categorized as zooplankton, macrobenthos, or fish, identified to genus, counted, and measured (nearest 0.01 mm for zooplankton; nearest 0.1 mm for other organisms). Saugeye stomach contents were oven-dried separately by category (60°C, 24 h) and weighed (nearest 0.001 g).

Saugeye survival and growth.—Petersen population estimates (Ricker 1975) of age-0 saugeyes were made from 16 through 27 September 1991 for all reservoirs. The entire shoreline of each reservoir was electrofished twice, and population estimates were completed within 2 weeks. All saugeyes were measured (nearest mm, TL) and 10 saugeyes per centimeter size-group per boat were wet-weighed (nearest 0.1 g).

Results

Transportation and Handling

Immediate poststocking (1-h) mortality for age-0 saugeyes was low (<2%) in the water near the stocking point. Conversely, saugeyes held in enclosures exhibited high initial mortality 5–10 d poststocking. Mortality was 18.9–63.5% among reservoirs and increased through time with each reservoir stocked.

Diets of saugeyes in the enclosures placed in Delaware Reservoir differed from diets of saugeyes at large in the reservoir. More reservoir saugeyes had empty stomachs than enclosed saugeyes (Pearson chi-square, $P = 0.017$). For saugeyes that did consume prey, more fish were consumed by reservoir saugeyes (Pearson chi-square, $P < 0.001$), and more zooplankton were consumed by enclosed saugeyes (Pearson chi-square, $P < 0.001$). Cannibalism occurred in enclosures but not in reservoirs.

Predation on Saugeyes

Of the predators sampled, only largemouth bass, smallmouth bass, and age-1 and older saugeyes consumed age-0 saugeyes (Table 2). Saugeye mortality from all predators varied from minimal to possibly substantial, depending on how long saugeyes were vulnerable to predation (Table 2). Although our predation estimates approached zero after 2 weeks, we estimated predation through 2 weeks poststocking (i.e., our sampling period) and 8 weeks poststocking. Our 8-week estimate accounted for possible low, continuous predation through much of the summer. We arbitrarily ended predation estimates after 8 weeks, given low documented rates of predation during 2 weeks poststocking. Saugeyes in Caesar Creek Lake, with the largest and most dense predator population, suffered greatest predatory mortality (28% and 75% of total stocked population during 2 and 8 weeks, respectively), whereas Lake Logan had the least (0%). Mortality of stocked age-0 saugeyes from pelagic predators also varied from low to possibly substantial (0 to 43%) in Wauseon 2 and Riley reservoirs sampled in 1992 (Table 2).

Prey Availability and Saugeye Diet

Zooplankton availability varied seasonally without a common pattern among reservoirs (Figure 1). Caesar Creek Lake had the highest peak density and biomass of zooplankton, whereas Delaware Reservoir had the lowest density.

Ichthyoplankton densities, (i.e., larval gizzard shad) peaked shortly after saugeyes were stocked in Pleasant Hill Reservoir and Caesar Creek Lake, whereas they peaked before saugeye stocking in Lake Logan and Delaware Reservoir (Figure 1). Both Pleasant Hill and Delaware reservoirs produced higher gizzard shad densities than either Lake Logan or Caesar Creek Lake. Non-shad ichthyoplankton densities were less than $0.15/m^3$ in all reservoirs on all sampling dates.

In reservoirs where saugeyes could be sampled within 1 month after stocking (Pleasant Hill and Delaware reservoirs), dietary analysis indicated that saugeyes gradually became piscivorous 1–2 weeks poststocking, before which they consumed zooplankton and invertebrates (Table 3). Gizzard shad were the most abundant fish in saugeye diets in all reservoirs except Lake Logan, where sunfishes *Lepomis* spp. dominated the diet, even though sunfishes were less abundant than gizzard shad in the reservoir.

TABLE 2.—Population and predation estimates of potential predators on age-0 saugeye in four Ohio reservoirs in spring 1991 and two Ohio reservoirs in spring 1992. Population estimates of largemouth bass in Caesar Creek Lake and Delaware Reservoir were calculated with the Petersen formula; all others were calculated with the modified Schnabel formula. Species that did not consume saugeyes were grouped and listed as "all" or "all others." Predation estimates included number of predators sampled, sum of all saugeyes recovered from predators' stomachs, and an estimate of the total number of saugeyes consumed by the entire predator population (absolute number and percent of stocked saugeyes) for both 2 (sample period) and 8 weeks poststocking for each reservoir.

Species	Population estimate (95% confidence interval)	Predation estimate: Predators sampled	Number of saugeyes in stomachs	Total number (%) of saugeyes eaten at 2 weeks	8 weeks
		Pleasant Hill (344 ha)			
Largemouth bass	805 (539–1,192)	122	7	1,694 (1.99)	13,565 (15.96)
Smallmouth bass	763 (310–1,527)	57	2	123 (0.14)	5,299 (6.23)
Saugeye	1,853 (920–3,474)	126	13	2,944 (3.46)	12,240 (14.40)
All others		11	0		
		Caesar Creek (1,145 ha)			
Largemouth bass	9,013 (7,132–11,382)	272	139	30,364 (10.68)	75,033 (26.40)
Smallmouth bass[a]	795	24	55	18,283 (6.43)	66,431 (23.37)
Saugeye	13,981 (6,842–24,566)	143	47	31,734 (11.16)	72,313 (25.44)
All others		123	0		
		Logan (162 ha)			
All		108	0		
		Delaware (526 ha)			
Largemouth bass	5,999 (4,675–7,680)	686	58	4,408 (3.52)	17,287 (13.81)
All others		181	0		
		Riley (12 ha)			
Saugeye	358 (228–513)	101	6	312 (9.42)	1,426 (43.05)
		Wauseon 2 (18 ha)			
White bass	1,262 (969–1,713)	9	0		

[a] Number of smallmouth bass in Caesar Creek Lake was estimated from the largemouth bass population estimate in Caesar Creek Lake (as in B. L. Johnson et al. 1988), because smallmouth bass recapture was minimal.

Saugeye Survival and Growth

Saugeye survival from stocking through autumn was 0.8–11.5% across reservoirs, with Delaware and Pleasant Hill reservoirs exhibiting highest survival (Table 4). Survival was poorest in Lake Logan. Mean length at the fall population estimate ranged from 165 mm TL in Lake Logan to 209 mm TL in Pleasant Hill Reservoir (wet weights: Table 4).

Percent transportation mortality (i.e., in the enclosure) and reservoir saugeye survival estimates through fall were unrelated ($r = 0.44$, $P = 0.570$). Saugeye survival was unrelated statistically to zooplankton density at stocking ($r = -0.36$, $P = 0.64$), peak zooplankton density ($r = -0.56$, $P = 0.44$), larval gizzard shad density at stocking ($r = 0.82$, $P = 0.17$), peak larval gizzard shad density ($r = 0.77$, $P = 0.24$), or saugeye wet weight in October ($r = 0.88$, $P = 0.12$). Though not statistically significant, high r values coupled with P values approaching 0.05, given the low sample size ($N = 4$), suggest that of the foregoing relations, larval gizzard shad density at stocking and saugeye wet weight can positively influence saugeye survival (Figure 2).

Discussion

We attempted to assess the degree to which different factors influence survival of stocked age-0 saugeyes. Transportation and handling mortality could not be determined with certainty because saugeye enclosures did not adequately simulate the reservoir environment. In Delaware Reservoir, diets of saugeyes in enclosures differed from diets of saugeyes at large, suggesting that prey availability differed between these environments. Enclosure saugeyes exhibited cannibalistic behavior, but reservoir saugeyes did not. Because enclosures floated, saugeyes had no access to cool temperatures, which probably put additional stress on this coolwater hybrid. Therefore, enclosure conditions likely overestimated transportation and handling mortality, which we believe was less than 20% and hence, we conclude that transportation and han-

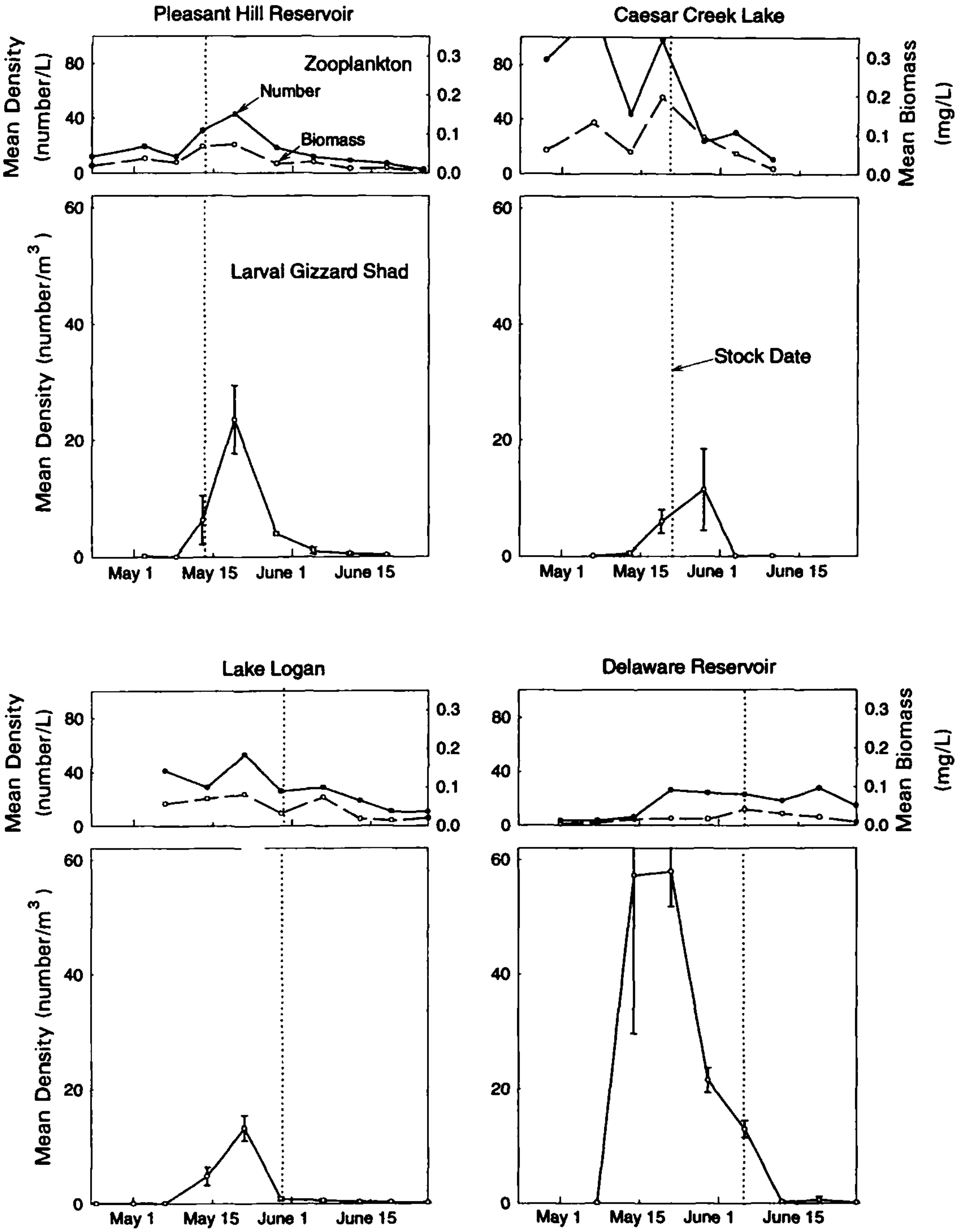

FIGURE 1.—Plankton biomass and density in four Ohio reservoirs in 1991. Top panels for each reservoir present mean density (number/L; solid line) and mean total biomass (mg/L; dashed line) for all zooplankton across all sampling sites. Bottom panels for each reservoir present mean (±SE) larval gizzard shad density (number/m^3) across all sampling sites. Saugeye stocking date for each reservoir is indicated by a vertical dotted line.

TABLE 3.—Percentages of three different prey categories in age-0 saugeye diets measured in grams per gram of dry weight for 1991 in two Ohio reservoirs. On each date, four or more saugeyes were analyzed. The stocking date for each reservoir is indicated in parentheses. Empty cells indicate that no samples were collected on that date.

Prey category	Percent of prey recovered from saugeyes on:					
	20 May	28 May	6 Jun	12 Jun	25 Jun	11 Jul
Pleasant Hill (14 May)						
Zooplankton	100	0.1			0	0
Benthos	0	23.2			0.1	0
Fish	0	76.7			99.9	100
Delaware Reservoir (4 Jun)						
Zooplankton			82.9	0	0	0
Benthos			17.1	0	0	0
Fish			0	100	100	100

dling mortality do not explain variability in saugeye stocking success in Ohio reservoirs.

Predation on stocked saugeyes by both inshore and pelagic predators was low in all reservoirs during 2 weeks poststocking. However, if predation continues into summer or if predators feed more than twice per day, then our low estimates of predation increase. Predators commonly feed twice daily (Swenson and Smith 1973; Hobson 1979; Becker 1983), and predation at the end of our sampling period was quite low (except for largemouth bass in Pleasant Hill). Consequently, we believe our assumptions of two feeding periods and only 2 weeks of predation are appropriate. Thus, we conclude that mortality from predation, although contributing to stocked saugeye mortality, does not account for a substantial proportion of it. Low predation on stocked saugeyes probably resulted from an abundant supply of alternate prey, namely gizzard shad (B. M. Johnson et al. 1988; Bremigan et al. 1991), which acted to mitigate predation pressure (Forney 1974, 1976).

Although prey densities and saugeye survival were unrelated statistically, we believe that ichthyoplankton availability ultimately drives saugeye survival. Zooplankton density at the time of stocking neither was related to, nor exhibited a positive trend with, saugeye survival. However, ichthyoplankton density at stocking was positively related to saugeye survival. For walleyes, recruitment is poor if gizzard shad are unavailable when walleyes should be switching from zooplankton to a fish diet (Momot et al. 1977). Interestingly, saugeyes did not become piscivorous immediately upon stocking. Because piscivory increases growth (Hokansen and Lien 1986; Wicker and Johnson 1987; Buijse and Houthuijzen 1992; Stahl and Stein 1994), and saugeyes of the sizes stocked could consume ichthyoplankton (Mathias and Li 1982; Stahl and Stein 1994), poor ichthyoplankton availability (spatially, numerically, or both; Stahl and Stein 1994) may have delayed piscivory and slowed growth of stocked saugeyes. Ichthyoplankton availability should increase survival because piscine growth and survival are related (though not significantly in this study; Gutreuter and Anderson 1985; Adams and DeAngelis 1987; Miller et al. 1988; Post and Evans 1989; Madenjian and Carpenter 1991; Madenjian et al. 1991), and age-0 growth is typically related positively to ichthyoplankton availability (Smith and Pycha 1960; Forney 1976; Carlander and Payne 1977; Adams et al. 1982; Carline et al. 1986; Persson and Greenberg 1990; Stahl and Stein 1994).

Exactly why saugeyes die remains elusive. On the basis of our data, high mortality did not result from transportation and handling stress or predation by resident piscivores. We could not document starvation in these productive Ohio reservoirs. However, because ichthyoplankton density and saugeye growth are related, prey density may influence saugeye survival.

Recommendations

In our view, managers should time their saugeye releases to coincide with ichthyoplankton presence. Although we cannot explain the mechanism of saugeye mortality, we believe that stocking fingerling saugeyes at (or perhaps 1 week before)

TABLE 4.—Fall wet weights and population estimates of age-0 saugeyes and percent oversummer survival in four Ohio reservoirs in 1991. Reservoirs are listed in order of stocking (see Table 1); standard errors for saugeye wet weight (N = 30 per reservoir) and 95% confidence intervals (CI) for fall population estimates are given.

Reservoir	Fall wet weight (g)		Number stocked	Fall estimate		% survival
	Mean	SE		Number	CI	
Pleasant Hill	68.1	8.2	85,000	9,197	7,602–11,359	10.8
Caesar Creek	38.0	2.2	284,237	10,720	9,059–12,894	3.8
Logan	34.7	2.4	34,241	270	169–492	0.8
Delaware	52.6	7.8	125,184	14,350	12,326–16,705	11.5

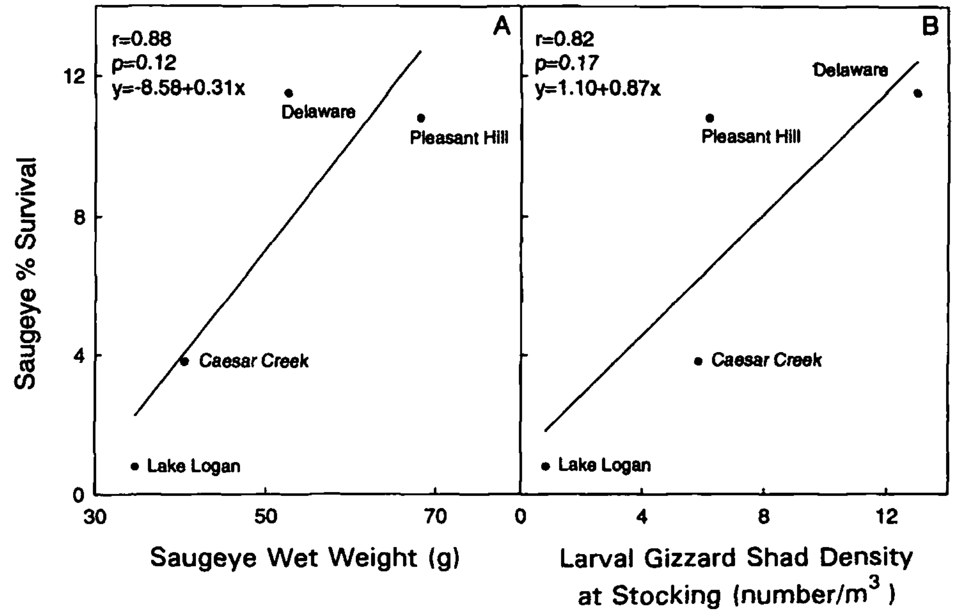

FIGURE 2.—Percent saugeye survival in Ohio reservoirs during May through October 1991 versus (A) October saugeye wet weight (N = 30/reservoir) and (B) larval gizzard shad density (number/m^3) at the time of stocking.

peak densities of larval gizzard shad will improve growth and survival. With this stocking strategy, managers maximize the availability of larval gizzard shad for age-0 saugeye consumption, allowing saugeyes to grow quickly through an early window of vulnerability to resident predators and likely minimizing other sources of mortality as well. One might predict larval gizzard shad peaks by coupling intensive field sampling with an understanding of what prompts adult gizzard shad spawning. Until these predictive techniques are available, historical data on appearance and persistence of larval gizzard shad should suffice. In Ohio reservoirs, populations of larval gizzard shad peak during 2 weeks from mid-May to early June. Hence, we recommend that saugeyes be stocked at this time to maximize survival, growth, and recruitment to the fishery.

Acknowledgments

We thank Randy Miller, Steve Graham, and Gary Isbell of the Ohio Division of Wildlife for administrative assistance, consultation, and limitless cooperation. We also thank all Ohio Division of Wildlife employees, too numerous to name, for their many hours of field data collection. Angela Rigsby, Katie Weakland, and Lisa Yako provided exemplary field and laboratory assistance. Nick Donovan, Mark Kershner, Rusty Wright, John Post, Tom Mosher, and an anonymous reviewer provided advice and constructive reviews. Our work was funded by Federal Aid in Sport Fish Restoration projects F-57-R and F-68-P administered through the Ohio Division of Wildlife.

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